

Introducing BEST

Learn that section 2

Learning involves a lasting change in pupils' capabilities or understanding.

2. Prior knowledge plays an important role in how pupils learn; committing some key facts to their long-term memory is likely to help pupils learn more complex ideas.

Learn that section 3

Ensuring pupils master foundational concepts and knowledge before moving on is likely to build pupils' confidence and help them succeed.

Learn how to section 2

Avoid overloading working memory, by: receiving clear, consistent and effective mentoring in how to take into account pupils' prior knowledge when planning how much new information to introduce Discussing and analysing with expert colleagues how to identify possible misconceptions and plan how to prevent these forming.

And - following expert input - by taking opportunities to practise,
receive feedback and improve at:

- Encouraging pupils to share emerging understanding and points of confusion so that misconceptions can be addressed.

Learn how to section 4

Providing opportunity for all pupils to learn and master essential concepts, knowledge, skills and principles of the subject.

Objectives

- Introduce the range of resources available in BEST.
- Identify how BEST resources can be used to support your subject knowledge development and pupil progress.
- Reflect on how you can introduce BESTS resources as part of the learning sequence within a lesson.

Introducing Best evidence science teaching (BEST)



BEST™

Best Evidence Science Teaching

Hundreds
of
resources

All based
on research
evidence

ONLINE,
OPEN-ACCESS
& FREE!

The image displays three sample worksheets from the BEST resource, each with a 'BEST' logo at the bottom.

- DIAGNOSTIC QUESTIONS:** Titled 'Is it a bird...?' and 'Colour change'. It includes a question about a yellow substance in a jar and a table for students to indicate if they are 'sure this is right' or 'think this is right' for four statements.
- RESPONSE ACTIVITIES:** Titled 'Comparing melting' and 'Steady force'. It includes a prediction task for a distance-time graph of a trolley's movement and a 'Watch the demonstration' section.
- PROGRESSION TOOLKITS:** Includes 'Production of sound', 'Cells and cell structures', and 'Substance'. The 'Substance' toolkit features a table for 'As students' conceptual understanding progresses they can:' with columns for 'Possible states', 'Melting observations', 'Boiling observations', 'Pure or mixture?', and 'Melting and purity'.

...to help teachers develop **evidence-based practices**

...to test and consolidate students' understanding of **key concepts** in science.

BEST (2021) available at https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching?gclid=CjwKCAjwo9unBhBTEiwAipC1181kZNkJY_5q1QXca-dKWWLyIHjTJRi6Vwe9JfiDYbFfk6kOWmCu8BoC3DQQA_vD_BwE

Best Evidence Science Teaching (BEST)

The resources have been developed from the best available research evidence on:

- common misunderstandings in science
- effective diagnostic questioning and formative assessment
- constructivist approaches to building understanding
- sequencing of key concepts.

The resources are developed by the [University of York Science Education Group](#).

The [Salters' Institute](#) has been proud to fully fund the BEST project since it began in 2016.

The [Institute of Physics](#) is now a co-funder of BEST, having supported the project since 2021.

We are providing [FREE](#) online access to the resources in collaboration with [STEM Learning](#) to support science teaching.

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BEST Curriculum maps

The titles of each column on the curriculum map refer to the big ideas in that discipline.

Within each BIG IDEA resources are divided into topics and then key concepts

CHEMISTRY AND EARTH SCIENCE (AGE 11-14)				
BIG IDEA CSU: SUBSTANCES AND PROPERTIES	BIG IDEA CPS: PARTICLES AND STRUCTURE	BIG IDEA CCR: CHEMICAL REACTIONS	BIG IDEA EEC: EARTH CHEMISTRY	BIG IDEA EDE: DYNAMIC EARTH
<i>Materials are either made of a single chemical substance or a mixture of substances which each have distinctive properties.</i>	<i>All matter is made up of atoms. The behaviour and structural arrangement of atoms explains the properties of different materials.</i>	<i>During chemical reactions, atoms are rearranged and new substances are formed.</i>	<i>Substances can move within and between the atmosphere, hydrosphere, geosphere and biosphere as part of large-scale Earth systems.</i>	<i>The Earth's crust is constantly changing as new rocks are formed and older rock is worn away.</i>
Topic CMS1 Properties and materials Key concepts: CMS1.1 Composite materials CMS1.2 Classifying materials				
Topic CSU1 Substances and mixtures Key concepts: CSU1.1 Substance CSU1.2 Solutions CSU1.3 Separating solutions	Topic CPS1 Substances and mixtures Key concepts: CPS1.1 Particle model for the solid, liquid and gas states CPS1.2 Particles in solutions			

Finding resources on BEST

- These tiles correspond to the big ideas in the curriculum map.



**Substances and
properties**



Particles and structure



Chemical reactions



Earth chemistry

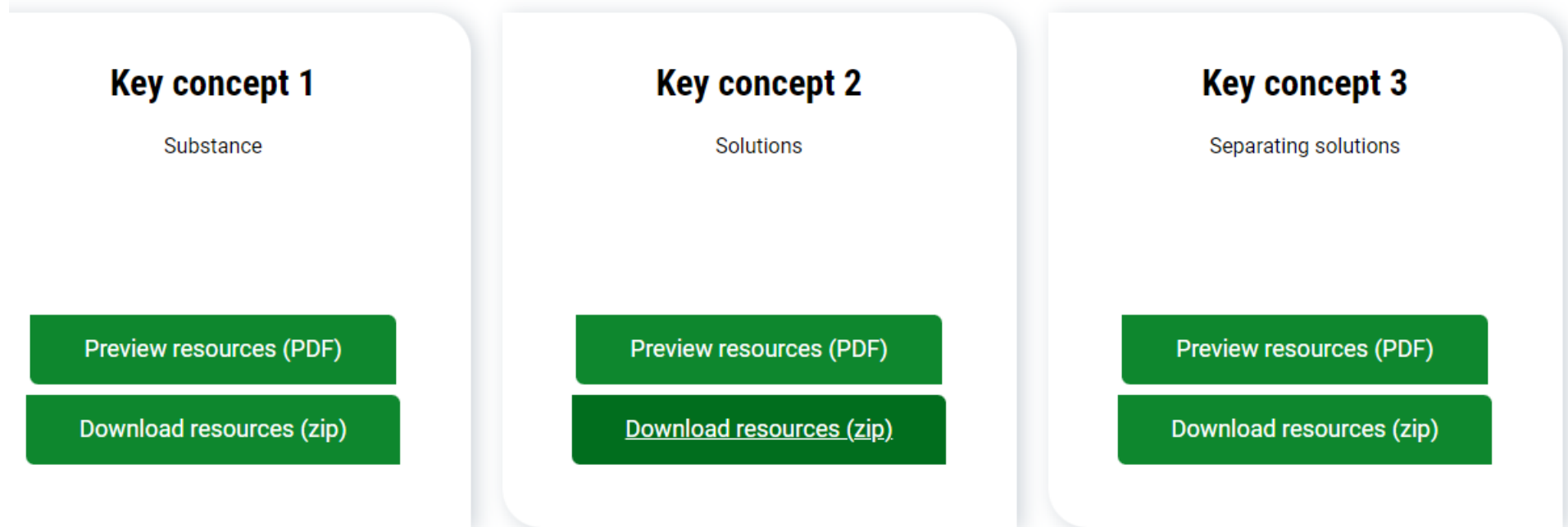


Dynamic Earth

Finding resources on BEST

- Each big idea is then subdivided into topics and key concepts.

Topic 1: Substances and mixtures



- Each key concept will have a progression map, a range of diagnostic questions and accompanying response activities

Task 1

- Split into subject specialism and work in pairs.
- In chemistry find a resource on the pH scale.
- In Physics find a resource that tests misconceptions on building circuits.
- In biology find a resource on cellular respiration
- Download one of the diagnostic questions and accompanying response activity. Part of the task is choosing the most appropriate resource. There is more than 1. In your groups ensure you can justify why you chose that resource.

Evidence-informed progression

A **progression toolkit** helps you to test and consolidate understanding of a **key concept** in science.


Progression toolkit: Changing motion

Learning focus: A resultant force on an object can cause it to speed up or slow down, depending on the direction of the force.

As students' conceptual understanding progresses they can:

CONCEPTUAL PROGRESSION				
Calculate the size and direction of the resultant force of two forces acting along the same straight line. P	Describe how quickly the speed of an object can be changed if acted on by resultant forces of different size. P	Describe how the speed of an object changes throughout the time that a resultant force is acting on it.	Explain how friction and other resistive forces can act to continually reduce the speed an un-propelled object.	Explain why friction and other resistive forces make it necessary to exert a constant force to keep an object moving at a steady speed. B
Diagnostic questions	How much is left over?	Drag race	Skydiving Rolling stone	Shopping trolley disaster! Supermarket dash
Response activities	Calculating resultant force	Steady force		Counter force Trolley racing

Key:
P Prior understanding from earlier stages of learning
B Bridge to later stages of learning



A research-informed progression pathway describes what students should be able to do as their understanding of the concept develops.

BEST (2021) available at https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching?gclid=CjwKCAjwo9unBhBTEiwAipC1181kZNkJY_5q1QXca-dKWWLyIHjTJRi6Vwe9JfiDYbFxx6kOWmCu8BoC3DQQAvD_BwE

Diagnose misunderstandings

Progression toolkit: Substance

A chemical substance has a characteristic melting and boiling point and can exist in different states.


Learning focus	A chemical substance has a characteristic melting and boiling point and can exist in different states.				
As students' conceptual understanding progresses they can:	<p>CONCEPTUAL PROGRESSION</p> <p>Recognise that a substance may exist in the solid, liquid or gas state, depending upon the temperature.</p> <p>Match observations of melting (or cooling) to the temperature at which they take place.</p> <p>Match observations of boiling to the temperature at which they take place.</p> <p>Distinguish the scientific use of the word pure from the everyday meaning.</p> <p>Distinguish a pure sample of a substance from an impure sample (mixture) by recognizing that a sharp melting point is characteristic of a pure sample of a substance.</p>				
Diagnostic questions	Possible states	Melting observations Cooling observations	Boiling observations	Pure or mixture?	Melting and purity
Response activities	Unusual states	Comparing melting		All that glitters...	Contamination mystery

Diagnostic questions help you to collect:

- evidence of where your students are in their conceptual progression
- evidence of common misunderstandings and preconceptions.

They can be used formatively to decide what to do next.

Body cells

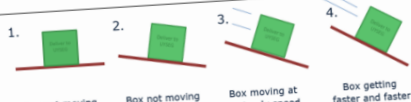


Which statement about the human body is true?

- A The body contains cells.
- B The body is a cell.
- C The body is made up of cells.
- D Cells are only found between the organs.

BEST

No friction



1. Which boxes have no friction?

- A They all have friction
- B Box 1 has no friction
- C Boxes 1 and 2 have no friction
- D Boxes 3 and 4 have no friction
- E Box 4 has no friction


2. Why do you think this?

- A There is no force pushing sideways
- B The surfaces are a little bit rough
- C There is movement
- D There is no movement
- E There is no force to slow the movement

BEST

Sugar solution

A teaspoon of sugar is dissolved in a glass of water making a sugar solution.



Read the statements in the table.

What is your decision for each statement?

	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong
1 The solution includes sugar in the liquid state.				
2 You cannot see sugar in the solution, so it is not there.				
3 You could taste the sugar in the solution, if it were safe to do so.				
4 The sugar has reacted with the water.				

BEST

BEST (2021) available at https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching?gclid=CjwKCAjwo9unBhBTEiwAipC1181kZNkJY_5q1QXca-dKWWLyIHjTJRi6Vwe9JfiDYbFxfk6kOWmCu8BoC3DQQAyD_BwE

Task 2

Working in Mixed groups. Role play one subject being the role of a teacher and others as the pupils.

Pupils are to complete the diagnostic quiz.

Based on the answers your pupils' give identify where your students knowledge base in in the progression map.

What will you do next?

Exemplar resources

There are a range of tools provided classic examples include

Diagnostic questions – which identify whether a student holds a misconception or not.

Confidence rankers which identify how secure pupils are in their knowledge

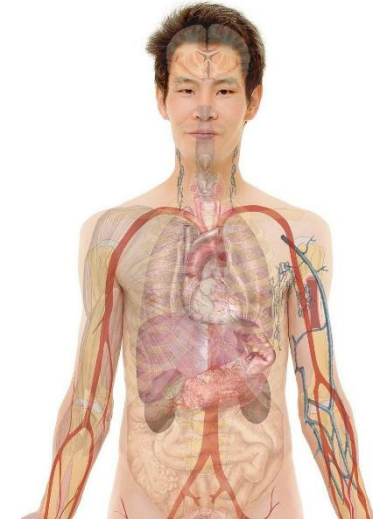
Focussed Cloze- an activity that gets pupils to utilise two scientific words that are often confused. These are structured to diagnose whether students are confused (the research suggests this may be the case).

Response- activities given after to respond to an emerging need.

Body cells

Simple
multiple
choice

Which statement about
the human body is true?



BEST (2021) available at
https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching?gclid=CjwKCAjwo9unBhBTEiwAipC1181kZNkJY_5q1QXca-dKWWLyIHjTJRi6Vwe9JfiDYbFvk6kOWmCu8BoC3DQQAvD_BwE

A The body contains cells.

B The body is a cell.

C The body is made up of cells.

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No friction

Two-tier
multiple
choice

BEST (2021)

1.



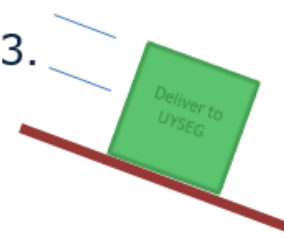
Box not moving

2.



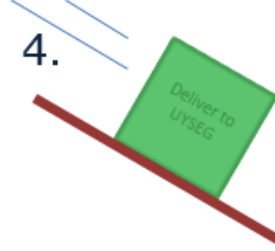
Box not moving

3.



Box moving at
a steady speed

4.



Box getting
faster and faster

1. Which boxes have no friction?

A They all have friction

B Box 1 has no friction

C Boxes 1 and 2 have no friction

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Sugar solution

Confidence
grid

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Respiration and breathing

BEST (2021)

Focused
cloze

Respiration is one of the processes carried out by living things.

Complete the sentences in the box.

You should only use **respiration** or **breathing** to fill each gap.



Moving air into and out of your lungs is called

Using food as fuel to provide energy is called

..... happens in all living things.

..... only happens in some living things.

..... does not happen in plants.

..... provides living things with oxygen for

Developing criticality and metacognition

Small
group
discussion

BEST (2021)

Some children talk about the C in CO₂.

Alex

C is short for the
element name carbon.

Arjun

C stands for the
substance carbon.

Zara

C means one
atom of carbon.



Kyle

C makes me picture a
lump of black coal.

Poppy

C is the symbol for the
element carbon.

To talk about in your group:

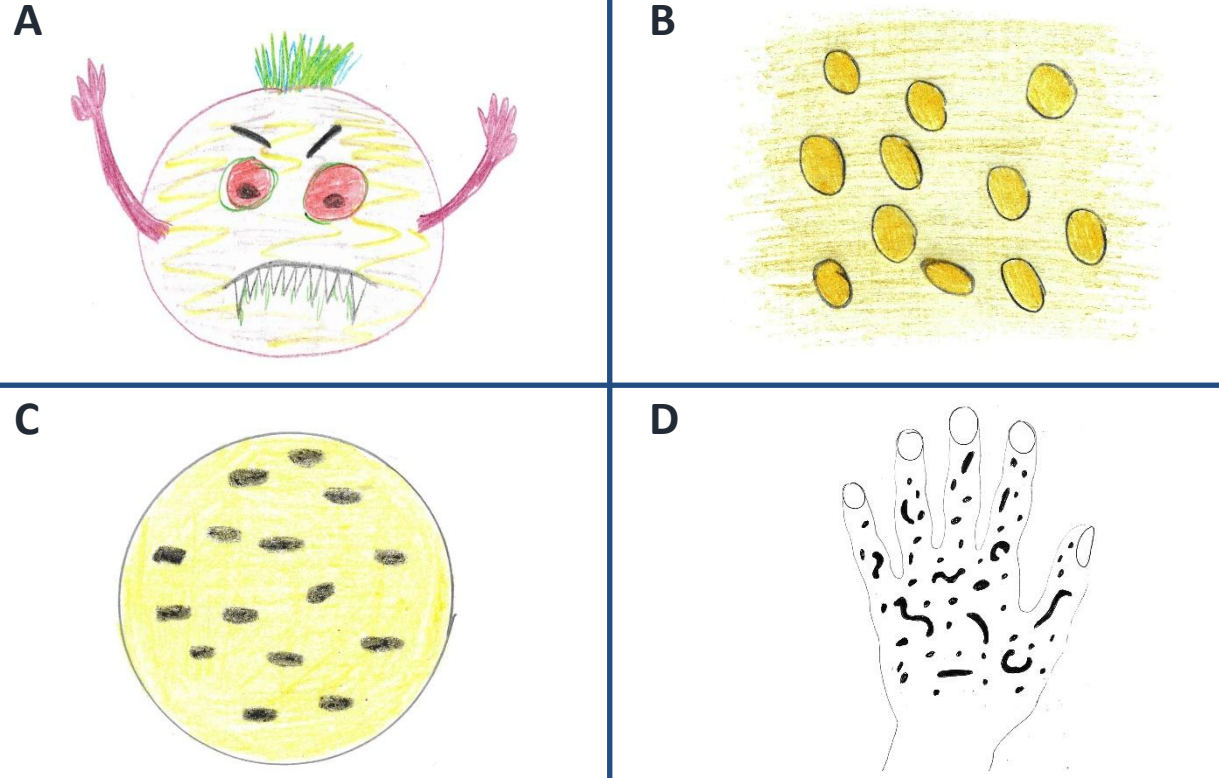
- 1 Who do you **agree** with?
- 2 Who do you **disagree** with, and why?
- 3 How would you explain the right ideas to these children?

Developing criticality

Critiquing a
representation

BEST (2021)

Some children were asked to draw what they think **bacteria** cells look like.



To talk about in your group:

- 1 Which is the **best** drawing of bacteria cells?
- 2 Why do you think it's the best?
- 3 What is **wrong** with the other three drawings?

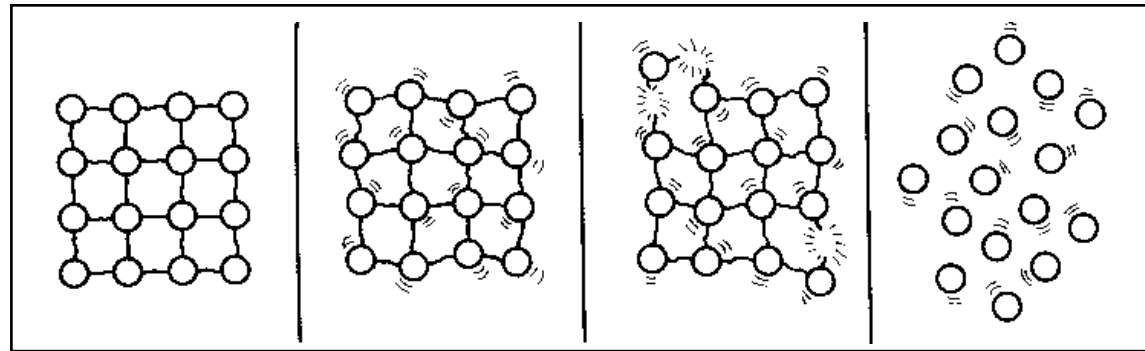
Highlighting the limitations of models

Critiquing a
model

BEST (2021)

The diagram is from a textbook.

It shows the **particle model** of a substance in the solid state melting so that the sample is in the liquid state.



To talk about in your group

State three ways in which you think the diagram is a **good representation** of a substance melting.

State three ways in which you think the diagram is **not an accurate representation** of a substance melting.

BEST (2021)

BEST and Improving Secondary Science

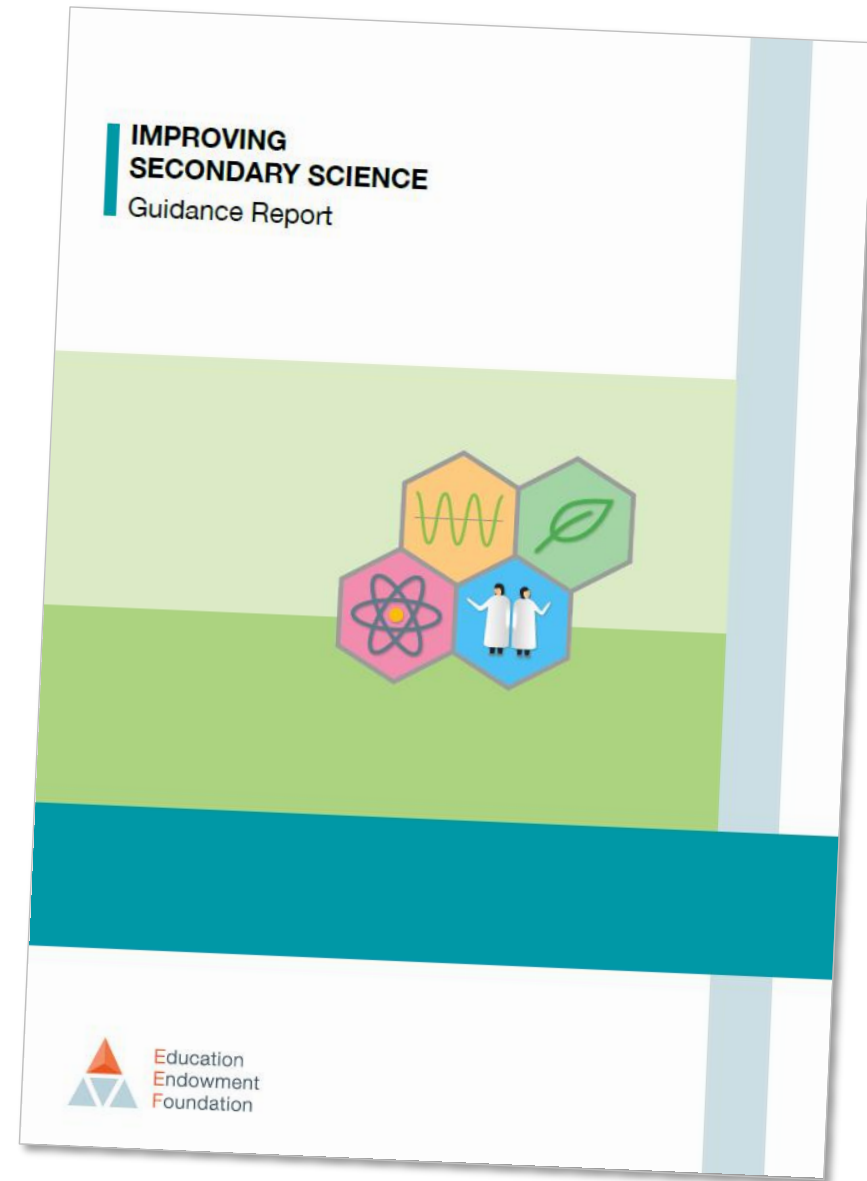
BEST (2021)

The **Education Endowment Foundation (EEF)** published a guidance report in 2018 titled 'Improving Secondary Science'

The report cites **Best Evidence Science Teaching** as a good source of:

- diagnostic questions
- activities that promote metacognitive talk and dialogue

The report makes seven main recommendations...





1

Preconceptions

Build on the ideas that pupils bring to lessons

2

Self-regulation

Help pupils direct their own learning

3

Modelling

Use models to support understanding

4

Memory

Support pupils to retain and retrieve knowledge

5

Practical work

Use practical work purposefully as part of a learning sequence

6

Language of science

Develop scientific vocabulary

7

Feedback

Use structured feedback to move on pupils' thinking

How can BEST help you work towards the recommendations of the **EEF** *Improving Secondary Science* report (2018)?

<p>1</p> <p>Preconceptions: Build on the ideas that pupils bring to lessons</p> <p>How BEST can help:</p> <p>Research summaries Research findings on common preconceptions and misunderstandings explained clearly</p> <p>Diagnostic questions Quickly identify the preconceptions and misunderstandings students have</p> <p>Response activities Adaptive teaching to meet students' learning needs and build understanding</p>	<p>2</p> <p>Self-regulation: Help pupils direct their own learning</p> <p>How BEST can help:</p> <p>Small-group discussion activities Engage students in metacognitive dialogue</p> <p>'Talking heads' activities Encourage exploratory talk</p> <p>Building explanations Help students to link scientific ideas through sequencing activities and explanatory stories</p>	<p>3</p> <p>Modelling: Use models to support understanding</p> <p>How BEST can help:</p> <p>Building understanding Explicit use of models help to explain difficult ideas and make predictions</p> <p>'Critiquing a representation' activities Help students to think critically about scientific models by identifying their benefits and limitations</p>	<p>4</p> <p>Memory: Support pupils to retain and retrieve knowledge</p> <p>How BEST can help:</p> <p>The 'big ideas' of science Developed through key concepts</p> <p>Key concepts Focus learning to reduce cognitive load with appropriately-sequenced learning steps</p> <p>Conceptual progression maps Focus teaching in students' 'zone of proximal development'</p>	<p>5</p> <p>Practical Work: Use practical work purposefully and as part of a learning sequence</p> <p>How BEST can help:</p> <p>Purposeful practical work Practical activities focused on developing understanding and key competencies</p> <p>'Predict-explain-observe-explain' activities Challenge students to apply what they know</p> <p>Cognitive conflict Practical activities to challenge students' misunderstandings</p>	<p>6</p> <p>Language of Science: Develop scientific vocabulary and support pupils to read and write about science</p> <p>How BEST can help:</p> <p>'Focused cloze' activities Consolidate understanding of key scientific terms</p> <p>'Re-phrasing' activities Students encouraged to express scientific ideas in their own words</p> <p>'Identifying evidence' activities Challenge students to identify the key ideas in passages of scientific writing</p>	<p>7</p> <p>Feedback: Use structured feedback to move on pupils' thinking</p> <p>How BEST can help:</p> <p>Progression toolkits All that is needed for progression without levels, including:</p> <p>Progression pathways Research-Informed learning steps for each key concept</p> <p>Diagnostic questions Provide feedback from student to teacher, to help you decide what happens next</p> <p>Response activities Challenge misunderstandings and build scientific thinking</p>
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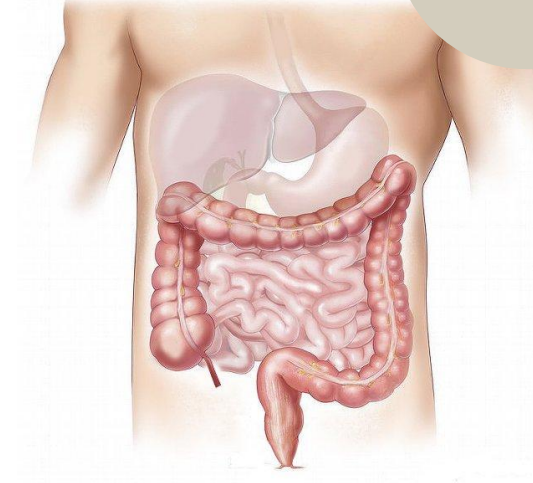
Moving through the digestive system

Simple
multiple
choice

BEST (2021)

Food we swallow moves through the digestive system.

What is the main thing that causes food to move through the digestive system?



BEST (2021)

- A Gravity
- B Contraction of muscles in the digestive system
- C Vibrations from body movements such as walking
- D Swallowing more food pushes it along

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1

Preconceptions

Build on the ideas that pupils bring to lessons

7

Feedback

Use structured feedback to move on pupils' thinking





4

Memory

Support pupils to retain and retrieve knowledge

RECOMMENDATION 1

Preconceptions

	Ineffective 	Intermediate 	Exemplary 
Developing knowledge about misconceptions	Many teachers are not knowledgeable about misconceptions in science and don't know where to find this information.	Teachers' knowledge of common misconceptions in science is inconsistent and they are not confident outside their specialism. Misconceptions are not considered as a standard part of planning.	Teachers are aware of the possible misconceptions in science. Knowledge is shared across the different science specialisms. Teachers know where to find this information and it is a standard part of topic and lesson planning.
Uncovering pupil preconceptions	Teachers do not know how to uncover pupil preconceptions and don't do this as standard practice.	Teachers understand the importance of uncovering preconceptions and have started to use pedagogies to do this.	Uncovering pupil preconceptions is a core part of topic and lesson planning. Teachers use a number of different pedagogies effectively, including group discussion and diagnostic questions.
Challenging misconceptions	Teachers are not confident in resolving misconceptions.	Teachers understand some pedagogies for resolving misconceptions, including using cognitive conflict and apply this in lessons.	Teachers understand that misconceptions are difficult to shift. They revisit these at different points and use a range of pedagogies to address them, including cognitive conflict, group discussion and argumentation.
For to	Ineffective  Many teachers are not knowledgeable about misconceptions in science and don't know where to find this information.	Teachers use formative assessment to check that misconceptions have been resolved and adjust teaching if they haven't.	Teachers use a range of formative assessment strategies (including low stakes quizzes, class tasks, diagnostic questions and discussion) to check that misconceptions have been resolved. If they haven't teaching is adjusted. Teachers understand that misconceptions are 'sticky' and test for these after a 'forgetting gap'.

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Following misconceptions to resolution	Teachers use summative assessment to check if misconceptions have been resolved.		




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Exemplary

Uncovering pupil preconceptions is a core part of topic and lesson planning. Teachers use a number of different pedagogies effectively, including group discussion and diagnostic questions.

Respiration and breathing

BEST (2021)

Focused
cloze

Respiration is one of the processes carried out by living things.

Complete the sentences in the box.

You should only use **respiration** or **breathing** to fill each gap.



Moving air into and out of your lungs is called

Using food as fuel to provide energy is called

..... happens in all living things.

..... only happens in some living things.

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Memory

Support pupils to retain and retrieve knowledge

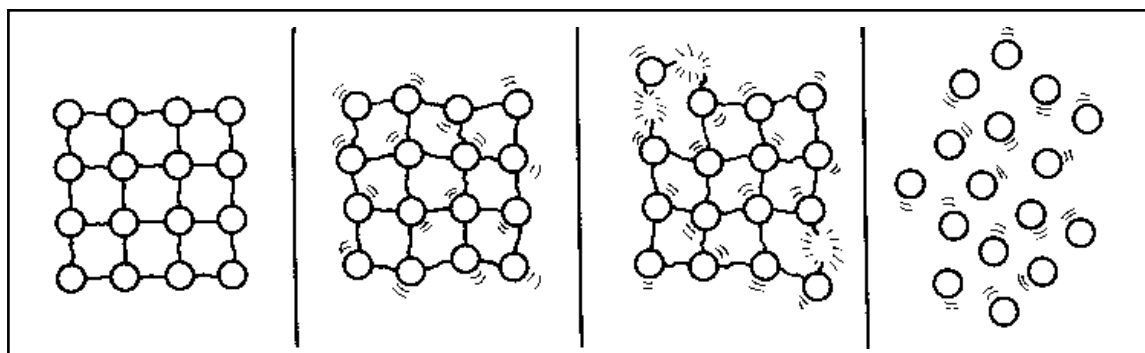
Particle model - melting

Critiquing a
model

BEST (2021)

The diagram is from a textbook.

It shows the **particle model** of a substance in the solid state melting so that the sample is in the liquid state.



To talk about in your group

State three ways in which you think the diagram is a **good representation** of a substance melting.

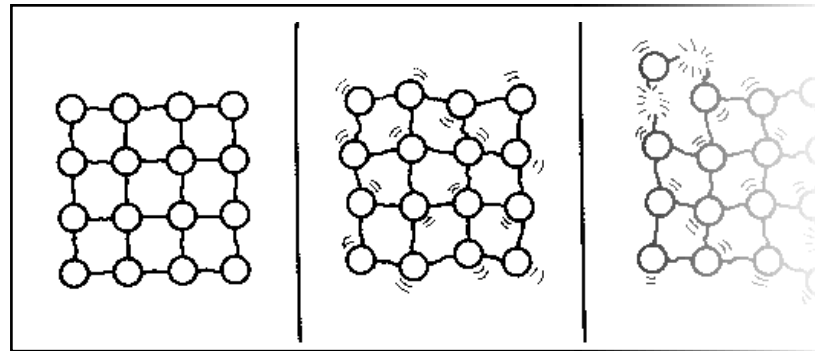
State three ways in which you think the diagram is **not an accurate representation** of a substance melting.

Particle model - me

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Modelling

Use models to support understanding

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Self-regulation

Help pupils direct their own learning

1

Preconceptions

Build on the ideas that pupils bring to lessons

7

Feedback

Use structured feedback to move on pupils' thinking

4

Memory

Support pupils to retain and retrieve knowledge

Task 3 potential limitations

Some children talk about the C in CO₂.

Alex

C is short for the element name carbon.

Arjun

C stands for the substance carbon.

Zara

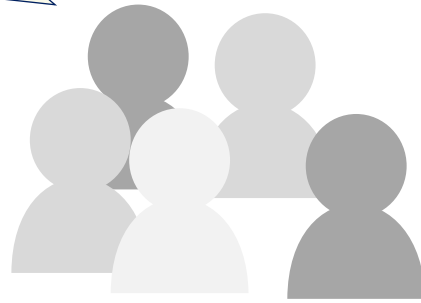
C means one atom of carbon.

Kyle

C makes me picture a lump of black coal.

Poppy

C is the symbol for the element carbon.



To talk about in your group:

- 1 Who do you **agree** with?
- 2 Who do you **disagree** with, and why?
- 3 How would you explain the right ideas to these children?

The purpose of this task is to promote dialogue amongst the students?

What action do you need to take? How do you support the pupils move on from simply saying, they are all correct?

How do you foster dialogic talk?

SMART targets

- You have previously had a lecture on self efficacy and SMART targets.
- In your portfolio of evidence that is due in December you will need to show evidence of how you have:
 - Improved your subject knowledge.
 - Used theories on how pupils learn to frame your practice.
- What SMART target can you set yourself and how can you use BEST to evidence that progress?

References